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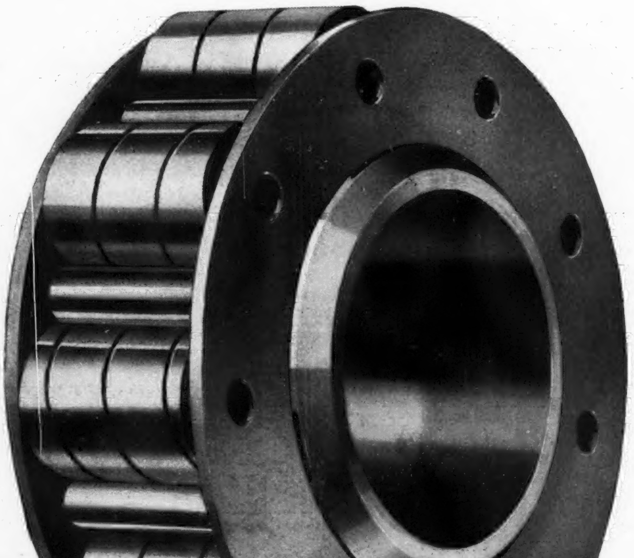
CONTENTS



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Applications of Electricity to Agriculture*

UNDER this subtitle, with the shorter but somewhat misleading phrase "electro-farming" as the main title, R. Borlase Matthews presented a paper before the (British) Institute of Electrical Engineers. The complete paper, together with an appendix and extensive discussions, appeared in the *Journal* of the Institute, issue for July, 1922. This journal is regularly obtainable from Spon & Chamberlain, 123 Liberty Street, New York City, this being mentioned for the benefit of readers who may desire to secure the paper and discussions in their entirety, since the following material can at best represent the entire matter only in a fragmentary way.

In the interest of brevity the applications of electricity which are in the aggregate perhaps the most important will not be referred to for the simple reason that they are obvious. So also will most of the technical details and statistical data which enrich the paper, as well as matter not seeming to have immediate value to agricultural engineers in America. It will be understood that the paper and discussions have to do with distinctive British farm methods and conditions, although experience and experiments in continental Europe are introduced freely to the extent that they throw light on the problems considered. The matter selected for mention and quotation is calculated more to stimulate interest regarding new or unusual applications of electricity rather than data pertaining to what is readily accepted.

One point raised in the discussion so strikes the reviewer that it is set forth as something to be borne in mind by the reader not only in considering this particular article but in contemplating the whole subject to which the article is devoted. It is to be noted that it conforms to the viewpoint of the foremost American authorities in regard to the agricultural practice generally designated as power farming.

"The reports of the electro-culture committee have quite definitely established, at least as regards certain crops, more particularly spring-sown corn crops, that an increase of about thirty per cent, both of grain and of straw can be produced.* * * * *It appears to me that there is much more to be hoped for from carrying on experimental work in that direction, namely, in augmenting what I call this miserable output from the land so as to get the margin in an increased product, than in trying to reduce the amount of labor. The possible increase of margin of profit is something like six times that arising from the possible saving on such a farm through the use of electricity as motive power."

The author states that nearly all of his experiments have been carried out on his own 600-acre farm, but that he has supplemented his own observations by a careful study of continental European methods. The general conclusion of the author is that any farm machine which revolves or has revolving parts can be operated by an electric motor more effectively and economically than by any other means. So sweeping is this pronouncement that it includes without discussion a large proportion of the mechanical operations on his farm. Among those enumerated some call for mention because they introduce ideas little known, or at least little considered, in this country. Among these may be mentioned electric lighting for intensive feeding of sheep, pigs, poultry, and other stock during the winter; electric refrigeration, which the author mentions in connection with the dairy but which in this country, at least, would be of equal importance from the standpoint of the farm home; electric sterilization of milk, either by electrolytic bath or mercury vapor lamps; electric thermo-couple long-distance thermometer for tuberculosis tests of cows and pigs; electric branders for marking cattle; electric fans for driving off flies in the cow houses; hay drying in wagons by electrically operated blower; corn-sheaf drying with electrically operated blower; electro-culture by high-tension, high-frequency electrical discharge, ozone treatment, and mercury vapor lamp treatment to induce better growth, to destroy insect pests, and to

*Abstract of paper appearing in the Journal of the (British) Institute of Electrical Engineers for July, 1922.

A farm house with electrical equipment is shown at the left. Power for generating the electricity is obtained from the pond on the right. Such developments are rapidly increasing

strengthen the plant for better resistance to the vagaries of the weather; electrolytic seed bath; treatment of seeds with ozone or with mercury vapor lamps; electrical germination of seeds; electrical seed dressing; electrical heat treatment of seeds; electrolytic conservation of greed foodstuffs; drying of hay in stacks by electrically-driven fans; and killing of mould growth.

Beginning with the relation of the engineer and the central station company to the application of electricity in farming, the author observes that "although, even under the best conditions, the load factor of an individual arable field is low, the completely electrically equipped farm has a load factor which is quite satisfactory from the central station point of view, especially when any farm is considered in conjunction with neighboring farms.

"A great deal of work that ought to be substituted by electric power is being done by manual labor on farms today. However, even progressive farmers are not usually aware that electricity can assist them until an electrical engineer studies the situation and shows them the possibilities. A difficulty arises here, in that but few engineers have sufficient knowledge of the intimate details of farming methods to develop electrical methods without considerable study, and sometimes a good deal of investigation, before success is attained.

"It does not take an engineer long to realize that the lines upon which farms are normally worked are based upon an abundance of cheap labor and a disregard for time. On the other hand, the engineer will soon find that there are really serious difficulties in modernizing a business in which the load factor of each machine, or possible machine, is so low.

"Continental experience shows that the annual consumption of electricity in farm buildings alone is proportional to the size of the whole farm and averages ten kilowatt hours per acre. If the farm were very modern there would be in addition a consumption of thirty-three kilowatt-hours per acre of arable land for plowing, plus one-third of this for cultivation, electro-culture, electric silage, harvesting, etc., or a total of forty-four kilowatt-hours per acre.

"While the main distribution may be at any pressure over 50,000 volts, in Europe a subdistribution of 10.000 volts, three phase, 50 periods is becoming standard. In America this subdistribution is at either 13,200 or 6,600 volts, three phase, 60 periods. The continental standard final pressure for farm supply is 380 volts for three phase motors, and for lighting, 220 volts single-phase (obtained between any phase and neutral conductor.) The electric distribution lines in such a case consist of four wires the fourth or neutral wire also acting as a guard. At road crossings tall iron-lattice standards are employed, of such height that if a wire gives way at either support it will not come in contact with ordinary traffic. In addition, each wire as it leaves the standard to cross the road is strengthened by one or two stays attached to insulators. It would seem to be a much simpler and more effective method than the use of cradles.

"For economic and other practical reasons the number and size of transformers are reduced to a minimum. It is found that for farm work a desirable minimum size is a 50-kilowatt transformer. From this transformer supply distribution lines can be conveniently run in any direction any distance not exceeding 2500 yards. To allow for the pressure drop, the motors which are installed at the ends of the lines are wound for a voltage ten to fifteen per cent lower than normal. Of course, when several motors are running the voltage drop has a marked effect on the brilliancy of the lights. However, it is rarely that the bigger motors are operated in the evening, when the lights are mainly in use in the farm houses. This scheme is, therefore, both practical and economical.

"Unquestionably the best and cheapest method by which the farmer can obtain power is from a public distribution network, but where this does not exist he must install a properly designed independent plant—for electricity is now indispensable on the farm.

"It is to be hoped that central power supply undertakings will not stipulate for rates based on the horsepower of the motors connected. Such rates discourage a farmer from installing a number of motors—in fact, in America in certain districts where such rates exist, farmers are installing oil engines to reduce the number of their electric motors. After all it is the maximum demand that affects a public supply, and maximum demand meters, with a suitable time-lag, are reasonably cheap. With the aid of suitable technical advice it can be demonstrated to farmers that they can obtain better terms on a self-restricted maximum demand. Agricultural-implement manufacturers are already catering for this requirement by providing such machines as threshers in such a form that the work is carried out in two separate stages. * * * Fewer men are required to operate the small machine, although, of course, the whole process lasts longer. This, however, is not usually a disadvantage, in that the saving in wages for extra men more than compensates for the extra time taken. In this manner, and by the aid of self-restricted circuits, an average farm will offer a very satisfactory load for the central station.

"If a dairy herd of more than ten cows is kept, it is advisable to employ a motor-driven cream separator and also a milking machine. For the driving of the milking machine two to three horsepower is required. In these days milking machines have proved a very valuable asset to the farmer, and, where run under the direct supervision of the farmer or his son, are highly successful. Over nine thousand farms in New Zealand employ milking machines.

"On a small farm of under one hundred and fifty acres the barn machinery required can usually be driven by a one-horsepower motor. On a farm of one hundred and fifty to three hundred acres a 5-horsepower electric motor is most suitable, as the barn machinery on these farms is slightly larger. On farms of over three hundred acres at least 15-horsepower motors are required as still heavier machinery has to be driven, inclusive of a full-sized threshing set. A very good estimate can be formed of the power necessary to drive a machine by substituting a 1/8 to 2-horsepower motor for a man or two men or replacing a horse or two horses by one 5-horsepower motor."

Tables accompanying the article show the smallest, largest and usual sizes of motors used for individual drives of a large variety of devices used on farms, also the approximate output of typical electric motor-driven farm machines expressed in terms of the work done for each kilowatt-hour consumed. It is stated that portable electric motors are having a considerable vogue for driving the various machines about the farmstead, but that it is a moot point as to whether in the course of a year's use the value of the time lost in adjusting and fixing them would not pay the interest and depreciation on a direct-connected motor for individual drive.

"Portable motors have, however, one great point in their favor, that is, they enable new drives to be tried and experimented upon in cases of doubt.

"The author's experience on his own farm has shown that since installing electric lights in the cow byres milk loss due to spilling has practically stopped. In fact, the value of the milk so saved is more than sufficient to pay (at 4d. per kilowatt-hour) for the current consumed.

"It has been discovered by experiment that certain animals, for example, lambs and other stock, can be brought to an earlier maturity by carrying on the feeding for a few hours after sunset and also for a few hours before sunrise in the winter time in northern climates. Electric lighting is also being used very successfully in poultry laying houses, with the object and result of increasing the egg production during the

winter months when eggs bring the highest prices. Careful investigation seems to indicate that the hens do not lay more eggs per annum but by the use of electric lighting and consequent longer hours of feeding it has been conclusively shown that more eggs are produced at the time they are most in demand. From tests which have been made it would appear that ten per cent more eggs can be obtained during the winter months. In the case of the lighter breeds, such as White Leghorns, the increase may be up to twenty-five per cent. It should be noted that the cost of supplying electric lights from six A. M. to dawn and dusk to nine P. M. is only three-fourths pence per bird per year (or less than the value of one extra egg per bird).

"Various electrical methods have been employed to obtain sterile milk. These means include the passing of a high-tension current through the milk, but this is obviously dangerous under commercial conditions. Another way is to expose the milk to ultra-violet rays while passing over a capillary cooler. As these rays undoubtedly produce ozone, the author has experimented with the discharge of ozonized air over the surface of the usual capillary cooler. Ozone, of course, has a deleterious action on the milk if it actually passes through it. None of these methods is entirely successful. However, the question has arisen as to whether absolutely sterile milk is of advantage to anyone except the trader. Bacteriologists seem to be of the opinion that it is preferable that the milk be not quite sterile.

"Owing to the practically constant voltage of the normal electricity supply, the temperature of incubators can be regulated more accurately by the aid of electricity than by any other means. The usual control medium is adopted, namely, an ether wafer, which consists of a hollow metal expansion disk several inches in diameter filled with ether, adapted to adjust a resistance in series with the heater coils.

"The greatest advance in incubator construction is, however, the employment of electric fans for thoroughly circulating the air inside the apparatus. The warm air reaches every part of the egg chamber, keeping it all at the exact temperature which is known to be the best for satisfactory incubation—in fact, this system insures that exact temperature for every egg in the incubator, which is seldom approximated in any incubator of the single-tray type.

"The relative simplicity and reliability of the electric fan system, compared with ordinary methods, may be gauged from the fact that with the former one regulator and two thermometers are required for a 10,000-egg incubator, as against seventy-four or more regulators and a similar number of thermometers necessary with the ordinary mammoth incubator. Moreover, the electric fan operated incubator permits continuous factory-like hatching. The percentage of fertile eggs hatched is higher than is obtained in natural or other artificial processes; the author has averaged 83.5 per cent with a 2240-egg incubator—the first and only one so far in this country. Above all, the chicks are healthier and stronger. Eggs incubated in machines of the ordinary type have to be taken out of the apparatus and cooled once or twice every twenty-four hours, but under the electric-fan system the eggs require absolutely no cooling.

"Electric motors are now preferred for driving irrigation pumps, as they allow of the plant being placed in the best position and do not require skilled and constant attention.

"Plowing is one of the farmer's heaviest and most important jobs, and is accompanied by the usual difficulties as it is a seasonal demand. Much experimental work in electric plowing has been carried out, but no entirely satisfactory solution has been reached. Extensive practical work in Germany, Sweden, Italy and France has demonstrated sufficiently that the results are in favor of electricity as compared with animals, steam, or oil plowing tackle. The only important competitor of electricity is steam, under conditio where fields are very large, and even then the electric system has many superior advantages. In the case of small fields the electric system is undoubtedly the most advantageous on account of its great economy."

The author classifies and characterizes the various systems of electric plowing somewhat as follows:

(a) An electric accumulator plow; open to the objection that the equipment is too heavy, packs the land excessively, and cannot be used on soft ground.

(b) An electric motor operated plow with trailing supply cable; objected to on the score that the equipment is heavy, that there is considerable wear on the trailing cable, and that the electric cable winding gear is unsatisfactory.

(c) An electrically hauled plow on the Fowler steam system; its objections being the use of double rope haulage, large capital outlay, wide headlands required, trailing distribution electric cable, and the requirement of 80 to 125 horsepower. It is noted that this method is successful on a large scale.

(d) An electrically hauled plow on a modified Fowler system with a single winder, being a compromise between the system just mentioned and that which follows.

(e) An electrically hauled plow on the Roundabout or Howard steam system, characterized by single-rope haulage, reasonable outlay, a power requirement of 12 to 60 horsepower, and anchorage difficulties not nearly so great as with the Howard steam system. The author considers this the most practical for ordinary farms.

"The single-rope method of plowing, though old from a steam-tackle point of view, is comparatively new as an electrical method. The tackle comprises a single electric motor with two haulage rope drums, either of which can be driven by the motor as desired by the operator, while the other pulley pays out rope. The haulage rope is arranged by the aid of suitable pulleys to follow around the sides of the field to be plowed. At two corners anchored angle pulleys are provided. At the other two corners station pulleys are mounted upon carriages. An anchor rope is taken from each of these carriages to the side of the field. When the rope is pulled by the haulage set the pulley carriages are drawn along to the extent permitted by the slack in their anchor ropes. The balance plow is attached to the haulage rope between the two pulley carriages. The method of plowing is to haul the plow from one pulley carriage to the other. The balance plow is then turned over ready for the next set of furrows. Before starting the new run the anchor rope of the further pulley carriage is slackened out, this permitting this carriage to advance a distance equivalent to the width of the new set of furrows. As the plowing proceeds the pulley carriages gradually approach the hauling set.

"The system is well adapted to small fields as the haulage set enters only one corner of the field. Very large fields would be plowed in several sections. Once set up in the field, two comparatively unskilled men only are required—one to operate a tram-car type electric controller, and the other to work the balance plow. A large haulage set will plow from nineteen to twenty acres per day (on an average) as compared with nearly one acre with horses. Electric plowing sets can be used on much steeper ground than steam sets. Normally from thirty to thirty-six kilowatt-hours are consumed per acre, plowing three 12-inch furrows at once on average ground. The practical furrow length even in very large fields rarely exceeds four hundred and fifty yards, chiefly owing to the difficulty of signaling.

"The use of an electric motor drive for the binder (as developed by the author) meets the requirements of faster cutting and the possibility of cutting any kind of crop in any sort of condition, and tests on binders show that the draft is less. As the drive is not obtained from the bull wheel, the machine can be used in certain sections of the farm where wet ground has heretofore made the operation of the binder very difficult. The use of electric motors also permits the cutting

of heavy grain in the proper workmanlike way, when the binder has to be drawn at comparatively slow speeds, owing to the fact that the knives or sections run at a constant speed. In practice it is found that the use of electrically operated binders effects a considerable increase in the number of acres cut per day, which increase as a minimum may be anticipated to be at least from four to five more than the normal sixteen acres. The electric power for driving the motor is obtained from a dynamo mounted on the tractor, which hauls from one to three binders."

Commenting on the combined harvester-thresher used in this country the author states that this practice can not be used in Great Britain owing to the necessity for curing the grain, but he is of the opinion that it can be accomplished if proper drying and curing electric fan arrangements are provided at the farm buildings, adding that some tests to this end have already been carried out. He concludes that "obviously a combined harvester and thresher is essentially a machine to be electrically driven."

The object of electro-culture is to increase the harvest yield by stimulating plant growth. It is very difficult to determine what increase can be obtained by electrical means, because so many natural factors, whose exact influence is still imperfectly understood, also affect the results.

"On the whole, a careful comparison of a great many experiments under large-scale conditions shows that there is undoubtedly considerable improvement in electrically treated crops. An analysis of the results obtained at installations at various experimental stations in England, France, and Germany seems to indicate that an electrically treated crop may be reckoned on to produce at least ten per cent more grain, accompanied with a proportionate increase in the quantity of straw.

"The cost of current is negligible, so that the problem has little interest for the electricity supply undertaking. The chief question that really has to be considered is the commercial one as to what amount of capital is necessary to attain this increase in the crop. The cost of stringing the wire is not at all important for four or five pounds of fine wire is all that is required per acre, plus the heavier insulator-borne cable supports around the field. The serious factor is the cost of the transforming and rectifying apparatus. It is estimated that the capital cost of a one hundred-acre equipment would be about £4 per acre.

"By deduction from experiments which have so far been carried out, the most suitable arrangement for a commercial farm is to provide alternating current supply; a 100,000 volt high-tension, oil-cooled transformer; and a mechanical rectifier driven by a small synchronous motor. The overhead network should be placed fifteen feet above the ground. It would probably be necessary to operate such a plant only for about an hour in the morning and again in the evening, during the spring and early summer months.

"An interesting feature that seems to be allied with electrical treatment is the possibility of the destruction of insect pests. This destruction is largely brought about by the fact that, in the presence of a high-tension discharge, the antennae, wings, legs, etc., of the insects tend to rise and so become uncontrollable, causing these insects to fall helplessly to the ground.

"Various theories have been put forward to account for the effects produced, for example, that the discharge forms nitrogen compounds, ozones, etc., producing manurial or plant-feeding effects. However, the quantity of electricity used is so small that only an infinitesimal amount of manure or its equivalent could possibly be produced even under the most favorable conditions. In fact, the best results from electrification are always obtained from the land which is richest in nitrogen. Hence the author's deduction is that it is entirely a physical, stimulative effect. Whatever the cause, the fact remains that better results *are* obtained with electrically treated crops. Also the cost of carrying out the electrical treatment (apart from considerations of the capital required for the installation) is nominal.

"Some little time ago the author was invited to take part in what proved to be a successful experiment in hay drying carried out in Scotland where hay-making conditions may be said to be nearly always unfavorable. The grass was cut green, with the rain on it, and was immediately stacked in the standard type of rick used in the district, weighing about five tons. A wooden duct was led into the base of the stack, and air was blown through this by means of an electrically driven "plenum" fan. The rate of drying was in inverse proportion to the amount of moisture suspended in the atmosphere, no drying taking place when the atmosphere was saturated, though the passage of the air through the stack prevented it from overheating. The making of the hay occupied some thirty hours, sixty per cent of the weight of the grass having to be evaporated. Smoke was introduced to the stack through the fan intake and appeared uniformly all over the stack, demonstrating the effectiveness of the simple duct.

"Artificially dried hay looks better, has a better aroma than naturally dried hay, and its food or nutritive value is greater. Incidentally, when drying artificially is adopted the process can be made continuous instead of necessitating the concentration of a large amount of labor for a relatively short period.

"On the continent F. Ringwald has successfully dried hay in the hay wagons before transport from the fields to the barns. For this purpose a duct, provided with vertical galvanized sheet metal standpipes, is placed ready in the bottom of the cart before loading. If the hay-drying apparatus be combined with auxiliary arrangements for drying fruits, vegetables, hops, etc., it becomes a paying proposition for any farm, even when it is not used for hay drying in favorable sunny seasons.

"The latest development is electrical silage, of which there are already nearly one hundred examples in Germany. It is claimed that by this method the fodder is better preserved, as objectionable bacterial action is arrested before it has time to do any damage. Each silo has an earthed electrode fixed at the bottom and a live electrode is placed on top of the freshly cut green stuff when the silo is filled. Up to ten kilowatts is required for a silo about twenty feet in height and fourteen feet in diameter, and the time required is twenty-four to forty-eight hours. Ten tons of fodder require between 130 and 200 kilowatt-hours."

In a rather long analysis of farm power requirements, based on several years of farm experience, B. M. Jenkins says: "Electric plowing was much more seriously considered before the days of the tractor. Then it competed with steam plowing and is in some ways very similar, except that the steam plow tackle could be moved to the field by its own power and has not to be moved by horses nor did it require any distribution system. With a tractor that can travel out with its own plow, one man goes out into the field, starts to work, works by himself all day until he finishes the whole field, and then starts another field. All he has to take with him is a little paraffin and water. Apart from the work at the farm buildings, power is required for hauling and transport at any point over an area of one-half mile, and on the road to the station and market, and I think it will be found that the work can be done much better or more easily by tractors and motor lorries than by electricity. Of course, in the farm buildings, electric lighting is extremely desirable, and it is eminently suitable for driving the small apparatus, but a small oil engine will do it quite as well and is as portable."

Commenting on the matter of electro-culture, J. E. Newman in the course of his remarks said: "It is quite obvious that if the system were to come into practical use

the number of poles must be small and that the agricultural operations must be carried out underneath the wires. In actual practice the interference with farming operations is not so great as would be imagined. The distance has increased to eight chains by five chains, that is, one to every four acres, so that the poles cannot at present interfere very seriously with ordinary agricultural operations. In 1906, after preliminary experiments, I approached Sir Oliver Lodge and secured his cooperation and that of a big farmer in Worcestershire. We started a series of experiments in 1906 and have carried them on, with breaks due to the war and other causes, up to the present time, and they have been claimed to be the first practical trials of electro-culture, at any rate the first trials which could be considered practical from the farming point of view. Over the whole series we had an average increase of over twenty per cent, which included one year of drought when no increase at all was obtained. I do not by any means regard that as the maximum possible increase; there is still a great deal to be discovered in regard to electro-culture."

Space will not permit further quotations from the discussion which was extensive, but it may be observed that it developed differences of opinion as to the comparative desirability of electricity and internal-combustion-engine power directly applied for what may be termed portable power requirements and a considerable degree of agreement that electro-culture holds forth promise of a more productive and more profitable agriculture.

Relation of Leather Belting to Economical Power Transmission

By Claude O. Streeter

Mem. A. S. A. E. Mechanical Engineer, Graton & Knight Mfg. Co.

A CAREFUL consideration of the above subject is of vital economic importance and the purpose of this paper is to stimulate such consideration and encourage a careful investigation of this problem by a committee on belting of the American Society of Agricultural Engineers. The present seems a particularly opportune time for the Society to start this work, as the country is interested in conservation and the elimination of waste.

Waste of power and the consequent loss of production resulting from the use of fabric or rubber belting is known to exist and authentic data pertaining to these points are already available and can also be compiled even by the most skeptical, by simply taking speed readings of a drive equipped with leather belting and then equipping this same drive with any of the substitute beltings and making the same observations. The results thus obtained can be readily computed into any unit desired and a comparison made of the true values of the belting used.

The reason for the use of substitute belting on agricultural equipment is largely due to the erroneous idea that because substitute belting is lower in first cost than leather belting it is the more economical. The writer has asked manufacturers of agricultural machinery why other than leather belting was sometimes furnished on their equipment and has received almost invariably one or both of the following answers: (1) Because I can buy substitute belting cheaper than I can leather belting, or (2) because competition is so keen we find it necessary to keep the price of our equipment as low as possible and consequently must economize in every possible way. Belting is one of the possibilities and so we buy at the lowest price we can get.

As to the first reason, it is very true that substitute belts are lower in first cost than leather belts; it is also true that substitute belts are less efficient, and, therefore, more expensive per horsepower transmitted. (Facts given in subsequent paragraphs of this article will prove the truth of this last statement.)

This brings out the fact that the only reasonable basis for comparison of the relative merits of leather and substitute belting is not merely the cost per foot, but the cost per foot per horsepower transmitted. Such consideration will bring out the fact that the cost of substitute belting will range from 50 to 110 per cent higher than leather belting.

In regard to the second reason, the manufacturer who follows this policy would seem comparable to the drowning man who grasps at straws in an effort to save himself; the only thing he succeeds in doing is to tire himself out and work his own ruin. In other words, such reasoning is not sound and, therefore, cannot accomplish the desired result.

Right will prevail and the company with the superior product is sure to predominate; therefore, would it not be better to put the best into the product to insure the highest efficiency and charge an honest price for it, without regard to what the other fellow may do? If a machine can show superior production to its competitors, it will not take long before that fact is recognized.

Before cutting down on the quality of materials going into a product, it is well to be sure the materials being cheapened will not be a detriment to the product. In furnishing belting with his machines the manufacturer often gives little or no serious consideration to the belting equipment. Unfortunately to him a belt is a belt, the price, not the quality, being to a great extent the deciding factor, and he is moved to attempt economy by buying cheap belting. He neglects to consider that in his opinion he has built the best machine possible and is equipping this fine machine with cheap belting, thereby impairing its productive capacity and increasing the cost of upkeep.

In discussing this subject of belting with operators of agricultural equipment, the writer has asked why rubber or rubber surfaced belting instead of leather belting was often used on certain machines. The lower cost is one reason advanced, and the other is that the belt is liable to get wet.

The first reason advanced has already been discussed. As to the second, the rubber belt was originally developed for wet conditions and was certainly an innovation before the advent of the waterproof leather belting. At that time it was not only cheaper but the better belt for wet conditions. However, with the advent of the modern waterproof leather, these conditions have been changed and the waterproof leather belt will not only outwear but operate more efficiently than rubber belting.

It must not be construed from the foregoing comments that any one leather belt is a "cure all" for all difficulties as such is not a fact, for the selection of the leather belt for any particular purpose must be made with a regard for the conditions under which it is to operate. This practice will insure the maximum satisfaction obtainable.

In selecting leather belts, it is advisable to consider quality first; failure to do so will result in poor service and unnecessary expense caused by the necessity of purchasing two or more belts, when one properly selected would have outlasted them. Disregard first cost entirely but be keenly

interested in the ultimate cost arrived at on a service and production basis.

There are several statements in the fore part of this article as to the superiority of leather belting over substitute beltings, and it will doubtless prove interesting at this point to have some facts presented to substantiate these statements. During the years 1915, 1916, and 1917, the writer conducted a long series of transmission tests in the physical laboratories of the company with which he is at present connected. The object of these tests was to obtain the correct power transmitting value of leather and substitute beltings for comparative purposes. At the completion of these laboratory investigations several belts were installed on drives in the factory, and the results obtained from these practical installations paralleled the laboratory results.

The results obtained from these tests were so important and interesting an addition to the data on power transmission by belting that the Leather Belting Exchange decided the subject was worthy of further investigation and study and consequently established an industrial fellowship at the Mellon Institute, University of Pittsburgh, for this purpose. At the completion of an extensive series of investigations at the Mellon Institute it was found that the results for the transmitting values closely paralleled those obtained by the writer. The tests conducted at Mellon Institute were conducted by two different men and the results obtained by each of them were practically the same.

In 1921 the Leather Belting Exchange decided to have another series of tests on this transmission value conducted by still another man and in a different location, thereby strengthening the value of the results obtained.

With this idea in mind the original fellowship was closed out and The Leather Belting Exchange Foundation established at Cornell University. A series of tests have recently been completed by this organization and the results obtained so closely parallel the three preceding tests mentioned that it can almost be stated the results are identical. These results positively present in a convincing way the fact that leather belting for the transmission of power is superior to substitute beltings.

The accompanying curves will present graphically the results obtained from the several tests mentioned. A careful study of these curves can but convince even the most skeptical of the truth of the statements in the fore part of this article in regard to the superiority of leather belting.

The curves show plainly that the substitute belts have reached their maximum transmitting capacity and will steadily decrease in value while the leather belts have not yet reached their maximum capacity although carrying from 60 to 100 per cent overload at 2 per cent slip.

All belt users know that leather belting improves in transmitting capacity with use, while the above curves clearly demonstrate that use can never improve the capacity of substitute belting as it is at its best when new and rapidly deteriorates with use.

Checking the results of these tests with the horsepower formulae furnished by the manufacturers of substitute belting, we find that when new most of these substitutes will transmit very nearly their theoretical capacity, but they reach this capacity at less than one per cent slip, and then drop off. When we consider the fact that to maintain a belt drive at 98 per cent efficiency is about all that is to be expected mechanically, the fallacy of endeavoring to use a belting material which loses its effectiveness at less than one per cent loss is apparent.

Some comment may arise as to the fact that different values have been established for the various belts investigated on these three tests. These differences are attributable to several causes among which might be mentioned, difference in speeds and tensions, but any method of analysis of these curves which may be employed will leave one fact and that is the superiority of leather over substitute belting for the transmission of power.

Fabric belting for conveying purposes is ideal and the most economical for this use. As stated before, in first cost fabric belting is cheaper than leather, and there are places in the transmission of power where fabric belts will prove nearly as satisfactory as leather belting, but these places are so few that it is very safe to say that fabric belting is cheaper than leather belting in first cost only.

If a drive is so poorly designed and the belt is subjected to such use that it only lasts a few weeks it may perhaps be better to buy the cheapest belt obtainable for use on such a drive. However, it seems that considering all points in such a case the economical thing to do would be to correct the faulty design so that a leather belt would prove the cheaper.

The presentation of facts and advancing of arguments as to the most economical type of belting to use can be carried on to great length, but the writer feels he has brought out enough to cause most anyone to realize that a careful consideration of the subject of belting for power transmission is advisable and reaching the correct solution may represent the difference between success and failure.

Extending the Use of Farm Septic Tanks

THE FARM mechanics division of the department of agricultural extension at the Pennsylvania State College is making a specialty of the installation of farm septic tanks. The type of tank that is being built is the Cornell single-chamber tank described by Prof. H. W. Riley in the June 1922 number of AGRICULTURAL ENGINEERING. The size used is the eight-person tank, 3 feet wide, 6 feet long, and 4½ feet deep, which covers practically every farm family. In cases where several houses use one tank the siphon is being recommended.

In this work a special effort has been made to build the wooden forms so that they can be used over again. The slogan "Save the forms" has resulted in eight counties having wooden forms on hand as against eleven counties which have built tanks and for various reasons the forms have been wrecked. Three of the eight counties have at least two forms in operation. Where the Farm Bureau has paid for the material used in the forms, the rental charge of $3 is returned to the county. In some cases the first farmer to start the work of building a septic tank keeps the form and he rents it to other farmers collecting the small rental.

A recent improvement in farm septic tanks just adopted by the Pennsylvania station consists in adding several strips to the Cornell type of form, which keeps the sides in line and gives a bearing for twelve bolts which are used to assemble the forms, saving nailing through the 2-by-4 corners from the inside.

For Better Farm Equipment

I HAVE been in the implement business for thirty years. I have seen implements become stronger, more powerful, very much more convenient, but I am forced to admit that I have not seen them become much more simple, much better engineered, or, above all, much cheaper in cost of manufacture.

Generally speaking, much of American mechanical improvement in the last two decades has been in this direction, but the movement seems to have skipped us. I doubt if there is an industry in which there is such a small accumulation of engineering data upon which to predict improved design. I think it is a true bill that we have moved by practical, strong arm methods with too little attention to the scientific side of the industry. —GEO. N. PEEK

Contraction and Expansion of Concrete Roads*

By D. L. Jantz

Jun. A. S. A. E.

THE purpose of this investigation was to determine the actual expansion and contraction movements of concrete and concrete roads, and to obtain data that might be available for the spacing of expansion or contraction joints in concrete roads.

The investigation consisted of both field and laboratory tests. In the field tests both the transverse and the longitudinal movements of concrete were measured. These tests were not run long enough to warrant definite conclusions but the data obtained thus far points toward valuable results. In the laboratory, contraction and expansion tests were made on concrete specimens of various mixes.

A gauge length of 20 inches was used in the measurements in order that the 20-inch Berry strain gauge could be utilized for obtaining the change in length of both the laboratory specimens and of the concrete road. For the gauge in the laboratory specimums 3/8-inch iron plugs, four inches long, were inserted in wet concrete flush with the surface and spaced 20 inches from center to center. After the concrete had set sufficiently, 3/64-inch holes were drilled in the plugs and the holes countersunk with a 1/8-inch drill. In measuring the gauge length the points of the instrument were placed in the countersunk holes which provided definite measuring points. For the field tests a more permanent plug had to be provided, therefore, a brass plug inserted in a half-inch pipe and fitted with a brass cup was used.

To set the instrument to read zero a standard steel gauge bar one-half inch square and 21 inches long was used. The gauge length of 20 inches was laid out on this bar by means of 3/64-inch holes and countersunk. The standard gauge bar, however, is not made of Invar steel and its length, therefore, varies with the temperature. As the change in the length of concrete in 20 inches is slight, a variation in the length of the standard bar would result in an incorrect reading. To correct the standard bar for temperature changes a similar gauge bar made of aluminum was used. Since the coefficient of linear expansion of aluminum is higher than that of steel the differences in lengths between the steel and aluminum bar varied with the temperature. By calibrating the two bars at various temperatures it was found that they were of the same length at 32 degrees Centigrade. This length was assumed to be 20 inches. By plotting the differences in lengths between the two bars as abscissae and the variation of the length of the steel bar from its length at 32 degrees Centigrade as ordinates a curve showing the correction for all temperatures was obtained readily.

A rectangular form of specimen 5¼ by 10 by 23 inches was used in order that it could be tested for expansion in an open boiler in the laboratory. All concrete mixtures were proportioned by weight with a standard brand of Portland cement, coarse clean sand, and soft limestone. The amount of water used was from nine to ten per cent of the total weight of the dry materials.

Specimen No. 1 was made of a 1:2½:4 mixture, which is usually used as a base course for two-course concrete roads. Specimen No. 2 was made of a 1:3:6 mixture. A proportion of 1:3:5 was used in specimen No. 3. This mixture is used as a base for brick roads. For No. 4 a 1:1½:2½ mixture was taken, which is usually used for the wearing course of concrete roads. No. 5 was made of a 1:3½ mortar to determine the contraction of mortar.

After construction the specimens were kept in the dry air of the laboratory for thirty days and the contraction during this time was measured. At the end of this period they were tested for expansion by heating them in water in an open boiler from 20 degrees Centigrade to 99 degrees Centigrade. After the expansion test they were dried thoroughly in air at a temperature of 45 degrees Centigrade. Then the specimens were allowed to cool to room temperature, after which they were soaked in water for 24 hours to determine the expansion due to moisture.

RESULT OF LABORATORY TESTS OF SLABS

Slab No.	Mix	Contraction in 30 days per cent	Coefficient of linear expansion	Expansion due to wetting in 24 hours, per cent
1	1:2½:4	.012	.0000058	.026
2	1:3 :6	.02	.0000068	.016
3	1:3 :5	.022	.0000070	.026
4	1:1½:2½	.022	.0000068	.014
5	1:3½	.041		

The high coefficient of expansion probably was due to moisture as the slabs were heated in water. The moisture test shows an expansion of from 0.014 to 0.025 per cent in twenty-four hours. The unit contraction for No. 1 in thirty days was 0.00012 inches per inch of length. If the modulus of elasticity of concrete is assumed to be 3,000,000 pounds per square inch in tension, the tensile stress that would be developed by a unit contraction of only 0.00012 inches would be 360 pounds per square inch. Unless free contraction of the concrete in a road were provided, some stress would be developed and cracking would result as its tensile strength would be exceeded.

For the field tests two sets of plugs were established. They were placed at different seasons of the year in order to determine whether there is any difference in the action of concrete when constructed at different temperatures. Set No. 1 was established southwest of Junction City, Kansas, on July 12, 1920. The plugs were set in the wet concrete during construction. The road is of a two-course construction. No expansion or contraction joints were provided. Plugs Nos. 1 and 2 were set transverse with the roads, while Nos. 2 and 3 set lengthwise. The object of setting a gauge length both across and lengthwise of the road was to determine the stress developed in case the road was not free to contract or expand lengthwise. The stress developed can be calculated from the formula:

$S=Ed$

Where S = unit stress, E = modulus of elasticity of concrete, and d = unit deformation.

The difference in the unit deformation between plugs Nos. 1 and 2 and Nos. 2 and 3 was due to deformation resulting from the stress.

Set No. 2 also was established on project No. 10 on November 20, 1920. The plugs were set in the wet concrete and in the same relative positions as at set No. 1. The same type of construction was used at this station. At each set a one-half-inch pipe four inches long and filled with mercury was set in the concrete for obtaining the temperature at each measurement.

Continued on Page 204

*A paper presented before the student branch of the American Society of Agricultural Engineers at the Kansas State Agricultural College.

The Exchange of Water in Northern Colorado

By R. G. Hemphill

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OF ALL the states, Colorado ranks second in the extent of its irrigated area. Over 3⅓ million acres of desert lands have been converted at an enormous cost when reckoned in labor performed, into highly productive irrigated farms during the past half century by poor settlers with little or no assistance from either the state or the nation. Although the gross revenue from these farms is something like $70,000,000 a year, the state has contributed next to nothing in aiding the settlers in this noteworthy achievement, the lands reclaimed by the reclamation service under the Federal government constituting less than 2¼ per cent of the total.

A development of this magnitude brought about by so humble an agency is interesting in many ways but chiefly as indicative of the trend of such enterprises when uncontrolled for the most part by state or federal restrictions. The effort ma(e in several western states to attach inseparably a water right to the land which it irrigates, known as the "doctrine of appurtenancy" may be cited as an example. Appurtenancy of this character has been rigidly enforced in Wyoming, and in that state, when it is desired to detach a water right from the land to which it is appurtenant, it is necessary to comply with statutory enactments and state administrative regulations. In Colorado, on the contrary, the state has not deemed it wise to impose restrictions of this kind and as a result the owners of water rights can exchange or otherwise dispose of them in a manner similar to other property. The conditions which render an exchange of water desirable in Northern Colorado, the methods followed in accomplishing it and the resulting benefits are ably presented in the following article.

It will be noted that the exchange of water under the Cache la Poudre River and its tributaries is made possible by the storage of part of the flood flow and other unused waters. Several years ago there were 135 reservoirs in this locality with capacities ranging from a few acre-feet to 18,000 acre-feet. These earthen reservoirs, wherein water can be cheaply stored, and the practice of exchanging water, have proved essential factors in utilizing to the fullest extent possible the land and water resources of this part of North Central Colorado.—SAMUEL FORTIER, associate chief, division of agricultural engineering, U. S. Department of Agriculture.

IN THE basin of the Cache la Poudre River lies one of Colorado's greatest farming districts. With only a small and uncertain water supply irrigation development has progressed until now, according to the last census, more than a quarter of a million acres are irrigated from the stream. Many factors were instrumental in bringing about this development, but it is probable that few were more productive of good results than the custom of swapping water available at one time or place for water available at another time or place. The first exchange, made thirty years ago, was followed by the extension of the practice to the point where it is common over the entire state and is specifically provided for by statute. Conditions were most favorable for exchanges in northern Colorado, and in the Cache la Poudre valley more than 80 per cent of the land is dependent on some exchange for adequate irrigation.

The annual precipitation in the basin ranges from 15 inches in the plains section to more than 20 inches in the mountainous section. About 45 per cent of this comes in the spring in the form of heavy general rains while the remainder is made up of summer "cloudbursts" and light fall and winter rains or snows. About the middle of April the snow and ice which have been accumulating for several months in the mountainous section of the district begin to melt and this water added to the runoff from the heavy spring rains produces the characteristic high spring flood of the stream. The crest of the flood occurs about the first week in June and the period covered by the rise and fall ranges from 6 to 10 weeks. The flow for the remainder of the year is comparatively small. Records for a period of 33 years show an average June discharge of 2087 second-feet and a January discharge of 50 second-feet. The mean annual discharge is about 500 second-feet.

During the early stages of irrigation development in this district there was an abundance of water to irrigate the native hay meadows and the small patches of grain in the bottoms. But following a period of colonization, expansion was very rapid and by 1881 it became apparent that the flow of the stream had been appropriated to such an extent that, while considerable water went to waste during the spring flood, the latest appropriators could not depend on securing enough water at the proper time to mature even these crops. The solution of the problem was clear and within three or four years a number of reservoirs had been built. The earlier appropriators escaped a shortage for several years longer but were finally compelled to provide for a reservoir supply of water when low prices and low yields from continuous grain cropping forced them to turn to alfalfa, potatoes, and other crops requiring irrigation late in the season at a time when no water could be secured directly from the streams except on the very earliest appropriations.

Conditions were favorable for the construction of reservoirs. The fall and winter flow of the stream and the excess runoff at times during the spring floods furnished the water supply, while scattered over the district were many good cites which could be developed at a very low cost. A few of these sites consisted of broad, flat, hollows partially closed at the lower end, but the great majority were natural depressions or basins with fairly impervious bottoms and sides which could be converted into storage reservoirs at an average cost under $5 per acre-foot of capacity. Their development required a cut at the bottom of which the outlet conduits

were placed, an embankment along the lowest rim of the basin to increase the capacity, a short inlet canal connecting with some distributing canal already constructed, and a short outlet canal connecting with another distributing canal or a natural channel leading to the river.

To utilize the best of the sites then available and to save the cost of long intakes many of these reservoirs were built below the distributing canals of the companies or individuals owning them. The problem of making the water stored in them available for use in the distributing canals above has been solved by an exchange of water, simple in some cases, very intricate in others. A simple exchange is exemplified by the handling of the water of Claymore Lake, a small reservoir owned by the Pleasant Valley and Lake Canal Company. In addition the company owns the Highline canal diverting from the river and serving as an intake for the lake as well as the distributing canal of the system. The outlet of the lake is too low to command lands served by the Highline and is connected with the river by a short canal. During the latter part of the season when the demand for water for late irrigation is heavy, the Highline may meet the demand by diverting 15 or 20 second-feet in addition to the amount to which it is entitled by its rights. At the same time an equal flow is turned from Claymore Lake so that the river reaches the next large appropriator below carrying as much water as if the extra diversion had not been made by the Highline.

All exchanges would be as simple were there enough water in the streams to provide for each one separately, but when it becomes necessary to draw on the reservoirs it follows that there can be very little water in the river. A very complicated system has grown out of the necessity of making this small flow exchange a large volume of stored water. The four large canals of the valley, the North Poudre, Larimer County, Larimer & Weld, and Greeley No. 2, irrigate a total of 175,000 acres on the broad bench lands sloping up to the Wyoming border. The lines of these canals are roughly parallel and differ in elevation by about 200 feet. The highest is the North Poudre diverting from the North Fork and having a water right with a priority number of 100. This system includes, among others, Reservoir No. 6 which is filled through the main canal and being too low to serve North Poudre lands, has an outlet which empties into the Larimer County Canal. The Larimer County Canal heads in the main river and has a water right with a priority number of 97. Long Pond is the largest of several of its reservoirs which are filled through the canal and have outlets too low to serve lands under it. These Larimer County reservoirs discharge into the Larimer & Weld Canal or the river. The Larimer & Weld Canal diverts from the river and has a water right with priority number of 88. The canal company owns no reservoirs but its stockholders as individuals are also owners of the majority of rights in Windsor Reservoir, which lies below the canal and is filled through it. The outlet of Windsor is too low to serve Larimer & Weld lands and discharges into the Greeley Canal No. 2, the lowest and oldest of the large canals diverting from the river. The earliest water right of the Greeley canal is an appropriation of 110 second-feet with a priority number of 37. It will be noted that the location and rights of these canals are such that the lower is always entitled to water before the one next above.

Except during the higher stages of the spring flood the North Fork carries only a small amount of water and the water rights of the Greeley Canal No. 2 are such that it may claim practically the entire amount to satisfy Priority No. 37 for 110 second-feet. Under ordinary circumstances this water would flow down the channel of the stream to be diverted directly by the Greeley Canal. Instead, it is diverted by the North Poudre Canal and used for direct irrigation. At the same time an equal amount of water is turned into the Greeley Canal No. 2 from Windsor Reservoir. If the North Poudre Company continues to divert 110 second-feet for a week it will have borrowed 1526 acre-feet of water belonging to the Greeley Canal, and the Windsor Reservoir will have paid it back for the North Poudre Company. The North Poudre Company then owes Windsor Reservoir 1526 acre-feet and, in order to insure its payment, holds that amount of water in Reservoir No. 6. The Larimer County canal now comes in, uses the water stored in Reservoir No. 6, and in exchange sets up in Long Pond a credit of 1526 acre-feet. When the water in Long Pond is turned into the Larimer & Weld Canal on demand and delivered to owners of Windsor Reservoir rights the exchange is completed and all accounts stand balanced. By this process the Greeley Canal has received all the water to which its rights entitle it; and the Windsor Reservoir, Larimer County Canal and the North Poudre Canal have each secured for use on higher lands the equivalent of 1526 acre-feet stored in low reservoirs. In other words, while the Greeley Canal has been left undisturbed in its rights the use of 1526 acre-feet of its water has served to make available for high lands a total of 4578 acre-feet stored in low reservoirs.

The above is an outline of a system which in actual practice is more extensive and involved. The North Poudre canal usually takes the entire flow of the North Fork and any debts which cannot be paid from Reservoir No. 6 may be paid, but less conveniently, from two or three other reservoirs which discharge into the river. The company also owns the Michigan Ditch which crosses a high mountain pass and brings water from the Michigan River basin into the Cache la Poudre basin. This water flows down the main river and is used to pay the river for water diverted from the North Fork. The Larimer County Canal may pay its exchange debts from eight different low reservoirs or with foreign water turned into the Cache la Poudre from the Michigan River, Grand River and Larimer River basins. Windsor Reservoir serves wholly or in part more than 30,000 acres under the Larimer & Weld Canal and it is imperative that the required amount of Windsor "exchange" be transferred upstream as early as possible each season. If this transfer lags for any reason, the water commissioner does not hesitate to hasten it by using available space in any reservoir to store water he takes from the river in exchange for Windsor water delivered to the Greeley Canal. Some idea of the extensive use and importance of exchanges may be obtained from the classification of the water supply of the Larimer & Weld Canal for 1916 given below. That year was normal and the classification represents fairly the exchanges to which the canal is a party each year.

Water Supply of Larimer & Weld Canal in 1916.

	Acre-feet
Diverted from river and Dry Creek on direct appropriation rights	60,157
Received from Little Cache la Poudre ditch on rented shares of that ditch	3,131
Stored water direct from Douglass, Terry and Replogle reservoirs	9,145
From Larimer County reservoirs to pay for river water taken on Larimer & Weld rights by Larimer County Canal at its head	3,950
From Larimer County reservoirs to pay for miscellaneous foreign and reservoir water diverted from river by North Poudre and Larimer Co. canals	2,668
From Terry Lake, Douglass, No. 8 and Larimer Co. reservoirs on Windsor Reservoir credits	12,022
Total	91,072

In an ordinary year the Larimer & Weld canal delivers water from six to eight different reservoirs. The rights of each of these reservoirs are supplied on demand of the individual owner and consequently the total demand on each reservoir fluctuates widely from day to day. To vary the

flow from each reservoir to meet the demand on it for the day would be impractical so it is the custom to pool all the stored water and draw it from the various reservoirs at a time and rate which will best promote the efficient and economical operation of the canal. This pooling of the supply is simply exchanging stored water most conveniently used at one time for stored water most conveniently used at another time. Thus, in 1916, when Douglass Reservoir water was turned into the canal it was used not only to supply current demands of Douglass rights but also to supply rights of reservoirs from which water had been advanced to supply Douglass rights for a month or more earlier in the season.

Another type of exchange is illustrated by the handling of certain reservoirs during the storage season. These reservoirs are filled during the fall or winter to about three-quarters of their capacity, or to the point where there is every assurance that the filling can be completed when the spring flood comes down. During the remainder of the storage season the small flow of the river which they forego is diverted to other reservoirs, which on account of small intakes or late priorities have less chance of filling. By this procedure both parties gain, the former chiefly by passing through the high winds of March with extra freeboard on the dams, and the latter by the increased supply due to the longer period water is available.

Exchanges of direct flow water within canal systems are common in this locality as elsewhere. Many canals find it necessary to prorate their supply of water in the latter part of the season when the river drops and some of their rights are cut. If the amount delivered per share decreased to a certain point it is customary for individuals to combine their allotments and use the total in rotation, thus securing a better irrigation and covering a greater acreage with a given amount of water.

Exchanges of stored and direct flow water within a single system are illustrated by the practice of the Greeley Canal No. 2. During the latter part of the season the amount of water this canal receives on its direct appropriations drops to the point where its delivery direct to the stockholders of the canal is no longer warranted. However, in its capacity as a common carrier, the canal is at that time handling a large amount of reservoir water for delivery to owners of rights in the reservoirs. So after the canal begins carrying stored water the small amount of river water received is used to supply reservoir demands and in exchange an equivalent credit is accumulated in either the Windsor Reservoir or the Cache la Poudre Reservoir. When this accumulation is sufficient, each share of the canal is credited with a day run of one second-foot which is delivered at any time upon demand of the stockholder.

It is difficult to assess the value of any one of the factors which have contributed to the advancement of irrigation in the valley but it is clear that much of the progress made was due directly or indirectly to the practice of exchanging water. The necessity for exchanges and their operation year after year brought about a better understanding between the various interests of the valley and started the growth of a spirit of community co-operation and fair dealing which has been a most effective aid in advancing irrigation development. The weirs put in and the gaugings made to insure fair exchanges in the early days of the practice familiarized the farmers with the advantages of measuring water and guess work distribution from river and canal, a most prolific source of strife and a real obstacle to progress, was ended shortly after by the installation of measuring devices at all points of division from the heads of main canals to the delivery gates of the individual farms. By the use of the low cost sites made available by exchanges the cost of stored water was kept well below the limit the land was capable of paying at the time and the progress of the district was never slackened by general failures due to high fixed charges which could not be met. At present the average cost of all water under the four canals previously mentioned does not exceed $1.25 per acre for the season. But the greatest service with which exchanges may be credited is the effect the storage provided by them has had in promoting a very high general duty of water in the valley. By storing practically all the water not needed for direct irrigation and using this reserve supply when and only when needed every second-foot of the mean annual discharge in a normal year is made to irrigate between 425 and 450 acres.

Contraction and Expansion of Concrete Road

Continued from Page 201

At set No. 1, placed in concrete laid in the summer, there was between August 15, 1920, and June 1, 1921, very little difference in the contraction or expansion of the road either longitudinally or transversely. The contraction of the road both across and lengthwise was 0.0058 inches or 0.0000051 inches per inch per degree Fahrenheit, or a contraction of 0.029 per cent in a change of 32 degrees Centigrade.

Set No. 2 was placed in wet concrete laid in the fall of the year. The temperature was a few degrees above zero. No contraction in the road was recorded as the temperature was never below zero when the set was visited. There was no expansion lengthwise of the road in a change of 24 degrees Centigrade, while transversely the expansion was 0.0048 inches, showing that the concrete was not free to expand lengthwise.

The unit expansion, transversely, was 0.00024 inches. Assuming that the modulus of elasticity of concrete in compression is 3,000,000 pounds per square inch, the compressive stress developed was 720 pounds per square inch in a change of 24 degrees Centigrade. The expansion per inch per degree Fahrenheit across the road is 0.0000055 inches.

The results as far as the experiment was performed seem to indicate that concrete laid at a temperature slightly above freezing should be provided with expansion joints as the expansion due to summer temperature greatly exceeds the contraction on drying out.

Concrete laid in the summer does not require expansion joints but should be provided with contraction joints at every twenty-five or thirty feet.

E. A. Stewart, associate professor of agricultural physics in the division of agricultural engineering, University of Minnesota, is doing some very interesting work in hydroelectric development for farm purposes. He has completed the installation of one small hydroelectric plant which employs electricity for a farm home, and which derives its power from a flowing well. The brake horsepower of the Pelton water motor is only 1-12 horsepower, and the plant charges the storage battery at the rate of 1 to 2½ amperes, depending upon the condition of charge in the battery. This plant then provides the farmer with approximately 36 ampere hours of electricity per day, which is the equivalent of running the ordinary gas engine plant about two hours per day for charging purposes. Prof. Stewart also reports that the division of agricultural engineering at Minnesota is extending investigations in sewage disposal. They have installed during the past summer six septic tanks of different designs and under different conditions for experimental purposes. These are in addition to a number that have been installed previously. This variety of installations will give a wide variety of desirable information.

Agricultural Engineering Development

A Review of the Activities and Recent Progress in the Field of Agricultural Engineering Investigation, Experimentation and Research

Edited by **R. W. Trullinger**
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HARNESS REPAIRING, L. M. Roehl, [Milwaukee, Wisconsin: Bruce Publishing Company, 1921, pp. 53, pl. 1, figs. 44.]

This is a popular handbook giving information on harness and harness repairing. It contains sections on making a harness thread, making a stitched splice, attaching a buckle with a Conway loop, attaching a buckle with rivets and the riveting machine, replacing a hame clip on a tug, repairing a trace or trace and tug with hame clips and link, replacing a broken hame staple, use of buckle shields, repairing the end of a trace with a wrought Concord clip, attaching heel chain to trace with a hame clip, repairing a trace and tug with a trace square and two wrought Concord clips, splicing a trace with a trace splicer or a metal plate, repairing bottom end of hame, harness stitching clamp to be used with metal vise on workbench, harness stitching clamp to be used with farm shop work bench vise, stitching clamp and farm work bench, farm shop work bench, stitching horse, saw horse stitching clamp, cleaning and oiling a harness, and harness repair tools and repair parts.

EXPERIMENTS ON AIR LIFT PUMPING, J. S. Owens, [*Engineering* (London) 112 (1921), No. 2908, pp. 458-461, figs. 9.]

This paper discusses the causes of loss of efficiency in air lift pumps and possible remedies, reports experiments made to elucidate causes of loss and to obtain data for improvement, and describes a special air lift pumping installation. The sources of loss discussed are slippage, friction, kinetic energy of discharge, and submergence. The experimental work dealt with the relation of diameter of bubble to velocity of rise through water and the conditions governing the size of bubbles, the effect of surface tension, and the oscillation of bubbles. From these results formulas and tabular and graphic data covering design and operation are deduced.

ECONOMY OF PLAIN AND REINFORCED PAVING BASES COMPARED. J. A. McCabe, [*Concrete* (Detroit). 21(1922), No. 2, pp. 49,50.]

Comparative laboratory studies of plain and reinforced concrete paving bases are briefly reported which showed that an 8-inch plain concrete pavement may be expected to be about 160 per cent stronger than a 6-inch plain concrete pavement with identical concrete, while a 6-inch reinforced concrete pavement will be about 300 per cent stronger than the 6-inch plain concrete, and will cost about the same as 8-inch plain concrete.

THE PRESERVATION OF SHINGLES, [Pennsylvania Station Bulletin, State College, 170 (1922), p. 26.]

It is stated that a thirteen-year comparative service test of redwood. western red cedar, chestnut, treated chestnut, southern yellow pine, and pitch pine shingles has indicated no difference in the durability of the shingles. The creosoted shingles of pitch pine and loblolly pine have remained in as good condition, so far as durability is concerned, as redwood or western red cedar. Considerable difference in the physical properties of the different materials, however, is evident. The pitch pine shingles were found to be warped badly and curled up at the edges and showed light streaks from inside the barn, causing some leakage.

HANDBOOK OF CONSTRUCTION EQUIPMENT, R. T. Dana. [New York and London: McGraw-Hill Book Company, Incorporated, 1921, pp. XV + 849, figs. 351.] This handbook brings together a large amount of information regarding construction equipment, its cost, and use.

DISPOSAL OF CREAMERY REFUSE, A. P. Wilson. [Journal of the Department of Agriculture and Technical Instruction for Ireland, Dublin, 21(1922), No. 4. pp. 399-411, pl. 1, fig. 1.]

Studies on the purification of creamery sewage my means of septic action and activated sludge treatment are described. The experiments were conducted on a small scale with sewage and septic tank effluents under varying conditions in forty-gallon barrels. Six barrels, each having a diffuser, were fitted and aerated. The septic tank effluent and the raw sewage were experimented with alone and combined with lime and with ground limestone. The septic tank effluent used was foul smelling and acid when added to the experimental tanks.

It was found that under the activated sludge treatment the odor and acidity disappeared almost at once. While the percentage of purification was lower than in the case of raw sewage the final effluent attained a much higher standard of purity. The effect of the addition of whey to the sewage was evident during the first period, and it influenced the composition of the septic effluent during the second period to a slight extent. The results indicate that the septic tank acts as a balancing tank equalizing the strength of the effluent. A great deal of the curd is retained in the septic tank as scum and sludge. When the sewage was submitted to preliminary septic action before treatment by the activated sludge process the oxygen absorption figure of the effluent was reduced to less than half that obtained when treating the fresh sewage. The preliminary septic action more than doubled the purification effected.

It is concluded that in many cases treatment of creamery sewage by the activated sludge process would be sufficient and that the plant could be operated in the open and close to the creamery without nuisance. Where further purification is necessary the effluent, after aeration of the sewage, can be treated in bacterial beds of either the contact or percolating type. Where a very high degree of purification is required, it is considered better to submit the sewage to slight septic action about two days before treating the liquor by the activated sludge process.

It is further concluded that no general rule as to the plan to be adopted can be laid down but that the method selected in each case must be decided upon after a careful examination of the local conditions.

A. S. A. E. and Related Activities

A. S. A. E. Representative on Special Committee of A. E. S. C.

IN RESPONSE to an invitation from the American Engineering Standards Committee for this Society to appoint a representative to serve on a special committee to consider the question of approval and sponsorship for future development of standard methods of testing concrete, President A. J. R. Curtis has appointed S. H. McCrory, head of the division of agricultural engineering of the U. S. Department of Agriculture, to represent the American Society of Agricultural Engineers. This is in connection with specifications submitted by the American Society for Testing Materials to the American Engineering Standards Committee for approval as "Tentative American Standard," which include:

Standard Method of Test for Unit Weight of Aggregate for Concrete (A S T M C29-21).

Standard Method of Test for Voids in Fine Aggregate for Concrete (A S T M C30-22).

Standard Method of Test for Organic Impurities in Sands for Concrete (A S T M C40-22).

College Section Election

THE ballot for the election of the elective members of the Advisory Committee of the College Section of the American Society of Agricultural Engineers has resulted in the election of O. W. Sjogren, professor of agricultural engineering and head of the department at the University of Nebraska and C. O. Reed, associate professor of farm machinery, Ohio State University. These members of the committee are elected for a period of three years, beginning January 1, 1923.

Personals

B. R. BENJAMIN has been transferred from the McCormick Works of the International Harvester Company to the experimental department in the capacity of assistant to the manager of the experimental department in charge of work on "Farmall," power-driven binder, power-driven implements, etc.

ARTHUR JOHNSON has been appointed assistant to the manager of the experimental department of the International Harvester Company, in charge of work on threshers, shellers, reaper-threshers, cultivators, drills, etc.

E. H. KIMBARK has been appointed assistant to the manager of the experimental department of the International Harvester Company in charge of work on binders, mowers, rakes, potato machinery, etc.

CLAUDE KINSMAN, formerly with Purdue University and later extension agricultural engineer at the University of Nebraska, will again be connected with the University of Nebraska during the winter months in connection with gas engine institutes, seventy-five of which have been scheduled for the winter.

JAMES KOEBER, of the division of agricultural engineering at the University of California, is developing and handling a course in farm mechanics for University freshmen, in which he is taking up the fundamental shop or mechanical operations that a farmer may be called upon to do, other than carpentry and blacksmithing, and reviewing mechanical principles as a basis for work later in agricultural-engineering courses.

E. W. LEHMANN, professor of farm mechanics and head of the department at the University of Illinois, reports that his department has three experiment station projects that they are getting under way. They include (1) an investigation of septic tanks; (2) investigation of the efficient harvesting and handling of grain; and (3) investigation on tractors. The first will be worked out in cooperation with the sanitary engineering department and the state water survey, and the other two will be worked out with the farm management department. Five experimental septic tanks have already been constructed, in three of which constant conditions will be maintained and observations made to try to arrive at some basic information in the correct principles of design. The other two tanks will be installed under actual farm conditions. Prof. Lehmann's department is also getting four extension projects under way. These include: (1) control of soil erosion, the object of which is to explain and demonstrate methods for preventing soil erosion, including methods of management for such soils; (2) farm building plans, the object of which is to provide farmers with blue prints showing well-designed plans of the principal farm buildings; (3) tractor schools, the object of which is to conduct schools for tractor owners and operators, giving them instruction in the construction, operation, and repair of tractors and gas engines; and (4) methods of improving the farm home, the object of which is to instruct farmers in matters pertaining to home improvements, with special emphasis on the selection and installation of equipment.

A. C. LINDGREN has been appointed manager of the experimental department of the International Harvester Company to succeed E. A. Johnston, who was recently appointed director of engineering.

WILLIAM L. ROCKWELL has been employed by the directors of the Hidalgo County Water Improvement District No. 4, at Edinburg, Texas, to make a valuation of the irrigation project in that vicinity controlled by the Edinburg Irrigation Company. The project includes two pumping plants and a canal system constructed for the purpose of furnishing an irrigation supply to 40,000 acres of land. The irrigators are not satisfied with the service rendered by the corporation and are entering negotiations to take over the project. The system has been in the making for about ten years, but at present only about thirty per cent of the acreage once tilled is under cultivation.

R. ALEX RUTHERFORD, consulting engineer, is at present, with the assistance of Yale University students, arranging detailed drawings of a variable speed device for tractors. This device automatically changes the speed of a tractor without stopping the machine. During the past year he has done a great deal of development work on a salt marsh ditching machine which he designed.

A. W. TURNER, associate professor of agricultural engineering, Iowa State College, is joint author with M. H. HOFFMAN, formerly extension professor of agricultural

engineering at the same institution and now a county agricultural agent located at Davenport, Iowa, of bulletin No. 96, "The Ridge Terrace," which is the sixth bulletin of a series on the prevention of soil erosion under Iowa conditions. The titles of the other bulletins are as follows: "Treatment of Hillside Ditches," "Checking Overfalls," "Filling the Large Ditch," "The Earth or Adams Dam," and "The Use of Concrete."

H. P. Twitchell is connected with the department of agricultural engineering at Ohio State University as extension specialist, his work consisting mostly of design and drafting of farm buildings.

F. A. Wirt, formerly professor of agricultural engineering at the University of Arkansas, has recently joined the advertising department of the J. I. Case Threshing Machine Company and will be engaged in sales promotion and advertising work. Mr. Wirt graduated from the University of Nebraska with the degree of B. S. in C. E. where he specialized in agricultural engineering. Following this he was professor of farm machinery at the Kansas State Agricultural College and later was head of the agricultural engineering department of the University of Maryland. He has also served as salesman, sales promotion specialist, and special representative for large farm-equipment concerns.

Ivan D. Wood, extension agricultural engineer at the University of Nebraska, reports that soil erosion work is now occupying a leading place among agricultural-engineering activities at that institution. The call for demonstrations on soil saving dams, brush dams, and terracing is almost more than they can fill. This interest was brought about largely by publicity given to the first two or three terracing demonstrations, as there was three years ago scarcely any interest in the subject.

O. B. Zimmerman, experimental engineer for the International Harvester Company, in conjunction with Berger Stockfleth, has finished a series of tests on a silage cutter using a new belt transmission dynamometer outfit developed by the engineering department. In this apparatus, mounted on truck wheels, is placed a 30-horsepower electric generator and a 30-horsepower motor with control switchboard. The generator is belted to a power unit, such as a tractor, and the current generated is utilized by the motor, which has a wide range of speed control. Recording and reading instruments cover voltages, amperes, watts, time, speeds, etc., enabling a very close record to be taken of all power and speed changes which occur. This outfit will be used in tests of all kinds of power-driven machines manufactured and using power within its capacity.

Wanted—Correct Addresses of These A. S. A. E. Members

Note: Mail is being returned from the addresses given below. These members, or others who know of their whereabouts, are requested to send the Secretary their correct addresses at once. Inasmuch as delivery cannot now be made, Agricultural Engineering will not be mailed until correct addresses are received.

George J. Baker, 112 Theodore Street, Detroit, Michigan.
Nelson C. Beem, Carey, Ohio.
Cyrus F. Breeden, Marshalltown, Ohio.
Claude S. Bristow, Elks Club, Portland, Oregon.
R. D. Chapman, 1336 Woodward Ave., Detroit, Mich.
George Collins, 461 Market Street, San Francisco, California.
George M. Duncomb, 136 S. Harvey Ave., Oak Park, Illinois.
J. C. Elliff, Box 115, Little Rock, Arkansas.
D. M. Emery, Illinois Hotel, Bloomington, Illinois.
H. A. Hatfield, Bank of Hamilton, Toronto, Ontario, Canada.
W. R. Killinger, 108 S. Franklin Ave., Riverside, Illinois.
M. W. McDonald, Charleston, West Virginia.
John T. Montgomery, Bliss, Oklahoma.
Arthur H. Pearsoll, 1350 Rosedale Avenue, Chicago, Illinois.
Jose Rivera, Matamoros 23, Mexico City, Mexico.
W. K. Runyan, 187 Peachtree Street, Atlanta, Georgia.
George W. Rynders, Box 127, Bradley, Illinois.
Lee Stewart, Spooner, Wisconsin.
J. H. Stowell, 3500 Colfax Ave., South, Minneapolis, Minnesota.
S. Y. Sweeney, 111 East Campbell Avenue, Roanoke, Virginia.
T. A. Toenjes, 1115 South Street, Waterloo, Iowa.
L. R. Van Volkenberg, Box 642, Fargo, North Dakota.
J. C. Weidrich, c/o Dempsey Hotel, Davenport, Iowa.
George G. Whitfield, Demopolis, Alabama.
A. A. Wolf, Y. M. C. A., Omaha, Nebraska.

Applicants for Membership

The following is a list of applicants for membership received since the publication of the November issue of Agricultural Engineering. Members of the Society are urged to send pertinent information relative to the applicants for the consideration of the Council prior to election.

Thomas D. Campbell, Hardin, Montana.
H. M. Parsons, Manager, Central Massachusetts Electric Company, Palmer, Massachusetts.

EMPLOYMENT SERVICE

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of Agricultural Engineering. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Non-members, as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

The Secretary receives at frequent intervals bulletins from the Engineering Societies' Service Bureau, 29 West 39th Street, New York City, listing the "positions open" as reported by member societies. Copies of these bulletins are sent to the "men available" listed below, as soon as received.

Men Available

MECHANICAL AND ELECTRICAL ENGINEER, graduate of Cornell University and Armour Institute, with nineteen years of practical experience in designing, manufacturing, and marketing gasoline engines, automobiles, motor trucks and tractors, having specialized particularly on internal-combustion motors and their application, prefers mechanical work cooperating with the different manufacturing and sales departments along the lines of sales engineering, or other work into which his qualifications would fit. MA-104

AGRICULTURAL ENGINEER wants position in southwest. Graduate of University of Illinois 1915, five years practical experience on Illinois farm with power equipment, two years in charge of the agricultural engineering department New Mexico College of Agriculture; considerable garage experience and service experience on unit power and light plants. Also one summer in Philadelphia battery service station. MA-106

AGRICULTURAL ENGINEER, graduate in mechanical engineering at Michigan Agricultural College, desires position teaching all kinds of farm machinery or automotive work, or with some farm-equipment manufacturer. Will be available April 1, 1922. Has served one year as instructor in tractors and trucks, and one year conducting service schools for a leading tractor manufacturer. Can furnish best of references. MA-110

AGRICULTURAL ENGINEER, graduating from University of Missouri at the end of present semester (available January 1, 1923), would like position teaching agricultural engineering work or with some company manufacturing farm equipment. Age 23. Unmarried. MA-115

Positions Open

DRAFTSMAN who has had experience in designing and manufacturing threshing machinery with reliable well-established farm-machinery manufacturer in central Pennsylvania. PO-1.

DRAFTSMAN to assist in designing threshing machinery and gas tractors with well established manufacturer of farm machinery in the East. PO-2.

STUDENT FELLOWS OR INSTRUCTOR IN DRAINAGE, the department of soils of the Oregon State Agricultural College will be able to use two student fellows, one in pure soils and one in soil irrigation and drainage work, if they can be promptly located, or an instructor in drainage if fellows are now secured. Write W. L. Powers, chief in soils, Corvallis, Oregon. PO-3.

AGRICULTURAL ENGINEERING

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

DECEMBER·1922

A Neglected Phase of Farming Progress

MUCH has been contributed to farm progress by such helpful agencies as the U. S. Department of Agriculture, State Agricultural Colleges, County Agents and the farm press.

It must be said, however, that all these agencies have neglected somewhat a most important phase of farming progress. All their effort for more fertile soil, selected and tested seeds, immunity from pests and scourges, and even better markets, is of little avail unless farmers have machinery and power with which to make their crops.

Better power, and the better use of power, alone enable farmers to take full advantage of improvements in agricultural conditions. For instance, thousands of farmers who know better are unable to do their fall plowing as well and as early as it should be done, because they lack the power.

Power limitations cost American farmers a staggering sum in crop losses every year—more than enough to buy tractors capable of fall plowing every neglected acre—and this is only one out of many counts in the indictment of insufficient or inefficient power as a cause of farm losses.

The most successful farmers today are those who have high grade power farming equipment and know how to use it to the best advantage. You will find these farmers making a practice of cost investigations, better study of crops, improvements in farming methods, and a general revision upward of all farm activities.

This is progress of the highest type, made possible only by the possession and use of adequate, efficient, economical power and machinery. To enable every farmer eventually to work with such power and machinery is the goal toward which this company has pressed forward steadily for more than eighty years.

J. I. CASE THRESHING MACHINE COMPANY
(Established 1842)
Dept. Z475 Racine Wisconsin

CASE

TRADE MARKS REG. U. S. PAT. OFF AND IN FOREIGN COUNTRIES.

POWER FARMING MACHINERY

NOTE: We want the public to know that our plows and harrows are NOT the Case plows and harrows made by the J. I. Case Plow Works Company.

A.S.A.E. Pins

EVERY member of the American Society of Agricultural Engineers should wear the A.S.A.E. emblem for two reasons: (1) As a means of identification, and (2) to promote the interests of the Society. To be a member of this Society is a mark of distinction; you can increase your own and the prestige of the Society by displaying the Society emblem on your coat lapel. The A.S.A.E. pins can be purchased at cost ($2.50) from the Secretary. Specify whether you prefer pin or button.

1921 Transactions

BY MISTAKE a few copies of the 1920 Transactions were sent to members, instead of the 1921 Transactions, which were mailed out the first week in November. If you received two copies of the 1920 Transactions, the last one during the first part of November, notify the Secretary at once to send you a copy of the 1921 Transactions.